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CRUISE RESULTS

CHARTERED VESSEL R/V *MORNING STAR* (CRUISE 2000-01)

BOTTOM TRAWL SURVEY OF EASTERN BERING SEA CONTINENTAL SLOPE GROUNDFISH AND SHELLFISH RESOURCES

JUNE 16 - JULY 20, 2000

The Resource and Assessment Conservation Engineering (RACE) Division of the Alaska Fisheries Science Center (AFSC) recently completed a bottom trawl survey of the groundfish and shellfish resources of the eastern Bering Sea continental slope (BSCS). This report summarizes the preliminary results of the survey.

ITINERARY

The survey was conducted aboard the chartered commercial trawler *Morning Star* from June 16 through July 20 (Table 1). A mid-cruise break was taken in Dutch Harbor on July 3 to exchange some scientific personnel and reprovision the vessel. The vessel worked along the continental slope of the eastern Bering Sea from Akutan Island toward the northwest, sampling predetermined stations at depths between 200 and 1,100 meters (Figure 1).

OBJECTIVES

The objectives of the 2000 BSCS investigation were somewhat exploratory in nature, to gain a familiarity with the area, habitats, and biota that we will be sampling in a biennial bottom trawl survey series that is proposed to begin in 2002. In order to help us design the best survey for the habitat and biota, we undertook a study of the fishing performance of two different configurations of the Poly Nor'Eastern sampling trawl. The objective of this study was to discern which rigging will allow us to sample the widest range of habitats and what possible limitations each configuration might impose on our ability to

capture benthic organisms. The specific objectives of this investigation were to:

1. compare the fishing efficiency and catch rate characteristics of two configurations of the Poly Nor'Eastern sampling trawl;

2. describe the bottom terrain and habitat of the proposed BSCS survey area, especially areas that present a challenge to bottom trawl sampling;

3. describe the composition, distribution, and relative abundance of groundfish and invertebrate resources of the BSCS;

4. collect biological samples from a variety of commercially and ecologically important species, including flatfish, rockfish, grenadiers, crabs, and shrimp; and

5. collect temperature profiles to relate changes in fish and invertebrate distribution among years to changes in oceanographic conditions.

VESSEL AND GEAR

The *Morning Star* is 45 m long and powered by a single main engine developing 1,710 continuous horsepower. The vessel is equipped with a full suite of modern navigation, fish-finding, and communication electronics. An experienced skipper and four-member fishing crew operated the vessel and the fishing gear, while a team of six scientists collected data and specimens from the trawl samples.

The RACE Division provided standardized trawls, bridles, and trawl doors for the survey. We used a reinforced version of the standardized Poly Nor'Eastern high opening bottom trawl. This sampling trawl features a 27.2 m headrope with twenty-one 30 cm floats and a 24.3 m long-link chain fishing line attached to a 24.9 m footrope. The nets used for this survey were reinforced with double-bar 5-mm mesh measuring 127 mm stretched-mesh in the body and 89 mm stretched-mesh in the codend. The codend was lined with a 32-mm stretched-mesh nylon liner to retain smaller organisms. Two hauls were made at each station using trawls rigged with different types of ground gear.

- The "mudsweep" ground gear was constructed of 20-cm diameter solid rubber disks strung on 16-mm high tensile chain.

- The "rockhopper" ground gear consisted of 46-cm diameter rockhopper disks separated by solid sections (approximately 35 cm long) of 25-cm diameter rubber disks.

Both trawl systems were fished with 1.83×2.75 m (6×9 ft) steel V-doors rigged with four-point bridles to enhance their stability at slow towing speeds and 55-m bridles between the doors and wingtips. The fishing dimensions of the trawl were measured using a Scanmar[1] net measurement system.

Data collected with each gear configuration will be compared to ascertain the relative ability of each to sample the rugged habitat of this region. We will also be analyzing catch rates and size compositions of key fish and invertebrate species to detect whether the different ground gears significantly affected our ability to sample the biota representatively.

We collected sea surface temperatures with conventional bucket thermometers and used a net-mounted Brancker Model XL200[1] microbathythermograph (MBT) to collect surface-to-bottom temperature-depth profiles. A continuous track of the vessel's GPS position during searching and running operations (observations every 30-40 seconds) was captured with our navigation software. More detailed position tracks (observations every 6 seconds) were collected during all fishing operations.

SURVEY DESIGN AND METHODS

The survey employed a stratified sampling design which placed 32 tracklines, drawn approximately perpendicular to the 200 m isobath, about 50 nmi apart between Akutan Island and 180°W longitude (Fig. 1). Each trackline extended from 183 to 1,100 m and was separated into five 183-m (100-fm) depth strata. Two depth strata on each trackline were selected for sampling stations. Station locations within each depth stratum segment were specified by choosing a target depth. Each station was sampled once with each trawl system, ensuring that adequate distance was left between the tows to prevent any possibility that the trawl tracks would overlap. The 64 trawl stations were

[1]Reference to trade names or commercial firms does not constitute U.S. government endorsement.

laid out so as to spread the sampling evenly across the depth range of each stratum.

The fishing operations to collect samples during all AFSC bottom trawl surveys have been standardized. Captains are instructed to try to maintain a constant fishing depth and fishing speed (in the case of this survey, 2.5 knots) and to set the gear so that, upon initial bottom contact, the trawl is as close to its equilibrium fishing speed and configuration as possible. Tows were designed to last 30 minutes between the time the net achieved a stable fishing configuration on bottom and the beginning of retrieval. Electronic bottom contact sensors (BCS) were hung from the footrope of the trawl to detect when the trawl was on bottom and monitor the actual duration that the trawl remained in contact with the seabed. Synchronized data streams from the GPS, BCS, Scanmar net mensuration system, and MBT were synthesized into a data set that describes and quantifies the sampling effort for each haul. This data set includes precise measurements of distance fished, fishing dimensions (width and height) of the net, bottom depth, water temperature, and bottom contact.

After retrieving the net, catches were sorted, each species was weighed and counted, and a variety of biological data and specimens (length, weight, age structures, and maturity of individual specimens) were collected. Samples were also collected from several species for more detailed studies of their biology (tissue samples, stomach contents, ovaries, etc).

RESULTS

One-hundred-seventeen tows were made during the survey. We successfully completed paired trawl hauls at 56 of the 64 planned stations (Table 2). Two stations in the deepest stratum were abandoned due to untrawlable bottom and we were unable to sample the six stations on the westernmost three tracklines because they had been placed in Russian waters. Four tows resulted in unsatisfactory performance (three due to gear damage and one due to the net "mudding down") and one extra tow was done at the deepest possible depth (1,400 m) to collect specimens of unusual species. Figure 2 presents sea surface and bottom temperatures by depth. Mean path widths of the mudsweep and rockhopper trawls were 14.94 and 14.02 m, respectively, with corresponding mean net heights of 7.24 and 8.35 m.

We identified 89 fish species, representing 32 families, and numerous orders of invertebrates in catches throughout the

survey. Specimens of many unidentifiable fish and invertebrates were collected for later identification by experts. Scientists used a digital camera and an on-board digital photo data base to improve the consistency of species identification.

The types and counts of biological data collected from fish species as part of the RACE mission are summarized in Table 3. We measured 32,792 fish from 38 species. Length-type conversion data was collected from eight species of skates (to determine the relationship between total length and disk width), two species of grenadiers (to determine the relationship between pre-anal fin length and total length), and shortraker rockfish (to determine the relationship between fork, standard, and total length measurements). Otoliths were collected from 11 groundfish species. These will be examined and ages will be assigned to each specimen. Length-weight data was collected from 3,465 specimens of 20 different species. Seven species of crabs were also measured during the survey including *Chionoecetes angulatus* (2,100), *C. bairdi* (158), *C. opilio* (43), *C. tanneri* (1,573), *Lithodes aequispina* (298), *L. couesi* (100), and *Paralomis multispina* (18).

Table 4 lists the dominant fish species caught by gear type and depth stratum, ranked in order of catch per unit of effort (CPUE, kg/ha). Pacific ocean perch dominated the catches in the shallowest stratum (183-366 m). Giant grenadier was the most abundant species in all other depth strata, accounting for over half of the catch weight in each of the four deeper strata. Relatively high catch rates of large flatfish (arrowtooth flounder and Greenland turbot) were seen in the two shallowest strata, but decreased at deeper depths. Popeye grenadier was quite important in the three deepest strata (550-1,100 m). Pacific sleeper shark was a major component of the catch in several strata, particularly in the middle stratum where two large catches were made.

Average catch rates of the mudsweep gear were higher than those of the rockhopper gear in all depth strata except the shallowest (Fig. 3). Average catch rates in the shallowest stratum were strongly influenced by large catches of Pacific ocean perch, and the largest of those catches (16+ t) was made with the rockhopper net. With Pacific ocean perch excluded, the average catch rate of the mudsweep gear in the shallowest stratum exceeded that of the rockhopper gear by 46%.

Figure 4 shows the unweighted size compositions (all depth strata combined) for six of the most commonly caught groundfish species, including arrowtooth flounder, Greenland turbot, giant and popeye

grenadier, sablefish, and Pacific ocean perch. These species exhibited generally unimodal length distributions, except Greenland turbot and sablefish which exhibited a broad range of sizes showing several modes.

For further information, contact Dr. Gary Stauffer, Director, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, National Marine Fisheries Service, 7600 Sand Point Way NE, BIN C15700, Seattle, WA, 98115-0070. Telephone (206)526-4170.

Table 1.--Vessel itinerary and scientists participating during the 2000 NMFS bottom trawl survey of Bering Sea upper continental slope groundfish resources.

Leg 1: 6/16 - 7/3

Bob Lauth	Field Party Chief	AFSC, Seattle
Gerald Hoff	Fishery Biologist	AFSC, Seattle
Ron Erickson	Admin. Support	AFSC, Seattle
Mark Blaisdell	Biological Tech.	AFSC, Seattle
Jan Haaga	Fishery Biologist	AFSC, Kodiak
Elaina Jorgensen	Fishery Biologist	AFSC, Seattle

Leg 2: 7/4 - 7/20

Bob Lauth	Field Party Chief	AFSC, Seattle
Gerald Hoff	Fishery Biologist	AFSC, Seattle
Jay Orr	Fishery Biologist	AFSC, Seattle
David Somerton	Fishery Biologist	AFSC, Seattle
Lisa Appesland	Fishery Biologist	AFSC, Seattle
Elaina Jorgensen	Fishery Biologist	AFSC, Seattle

Table 2.--Summary of stations occupied during the 2000 bottom trawl survey of Bering Sea continental slope groundfish and shellfish resources.

Depth stratum	Planned stations	Sampled successfully	Stations skipped	Stations with net damage
1 (183-366 m)	12	12	-	-
2 (367-549 m)	13	12	-	1
3 (550-732 m)	13	12	-	1
4 (733-914 m)	13	12	-	-
5 (915-1097 m)	13	9	2	1
All Depths	64	64	2	3

Table 3.--Summary of biological information and specimens collected during the 2000 NMFS bottom trawl survey of Bering Sea upper continental slope groundfish resources.

Species	Lengths	Weights	Otoliths	Tissues	Length Type Conversions	Maturity or ovary
Pacific sleeper shark	208	53				
Deepsea skate	2					
Bering skate	192	79			79	
Mud skate	147	93			93	
Black skate	100	39			39	
Alaska skate	11	9			9	
Aleutian skate	1026	302			296	
Commander skate	315	148			148	
Whiteblotched skate	302	197			197	
Whitebrow skate	149	83			83	
Okhotsk skate	1					
Arrowtooth flounder	1696					
Kamchatka flounder	1154					
Greenland turbot	1042	254	254			50
Pacific halibut	109					
Flathead sole	2104					
Dover sole	6					
Deepsea sole	47					
Rex sole	965					
Northern rock sole	34					
Sablefish	590	225	225			
Pacific grenadier	1259	156	156			
Giant grenadier	6059	37	37		11	
Popeye grenadier	8393	872	367		478	187
Blob sculpin	100					
Pacific cod	150					
Pacific flatnose	52					
Walleye pollock	334	87	87			
Atka mackerel	3					
Prowfish	16	16	16			
Twoline eelpout	2225					
Ebony eelpout	383					
Shortspine thornyhead	1789	404	404			50
Rougheye rockfish	83	51	51			
Pacific ocean perch	1089	114	114	98		
Light dusky rockfish	2					
Northern rockfish	1					
Shortraker rockfish	654	246	246		36	

Table 4.--The most abundant species in catches within each depth stratum. For each depth stratum, the 25 most abundant species are listed in order of relative abundance (ranked by catch weight) in hauls made with the mudsweep gear. Their CPUE and rank in hauls made with the rockhopper gear are shown alongside for comparison.

Depth Stratum 1 - 183-366 m	**Mudsweep Tows**			**Rockhopper Tows**		
Species Name	**CPUE (kg/ha)**	**Proportion of CPUE**	**Rank**	**CPUE (kg/ha)**	**Proportion of CPUE**	**Rank**
Sebastes alutus	187.46	0.497	1	904.07	0.874	1
Atheresthes stomias	49.46	0.131	2	41.49	0.040	2
Somniosus pacificus	39.07	0.104	3	16.05	0.016	3
Sebastes borealis	20.55	0.055	4	2.76	0.003	11
Hippoglossoides elassodon	14.84	0.039	5	15.14	0.015	4
Theragra chalcogramma	10.43	0.028	6	11.04	0.011	5
Hippoglossus stenolepis	7.64	0.020	7	10.83	0.010	6
Gadus macrocephalus	7.09	0.019	8	6.57	0.006	8
Reinhardtius hippoglossoides	6.81	0.018	9	2.87	0.003	9
Bathyraja aleutica	5.08	0.013	10	2.80	0.003	10
Glyptocephalus zachirus	4.60	0.012	11	2.72	0.003	12
Atheresthes evermanni	4.28	0.011	12	6.97	0.007	7
Porifera	2.60	0.007	13	0.40	0.000	21
Bathyraja maculata	1.81	0.005	14	1.26	0.001	14
Zaprora silenus	1.72	0.005	15	0.70	0.001	16
Bathyraja interrupta	1.55	0.004	16	1.13	0.001	15
Sebastes aleutianus	1.27	0.003	17	0.46	0.000	20
Bathyraja parmifera	1.13	0.003	18	0.54	0.001	18
Lithodes aequispina	0.83	0.002	19	0.59	0.001	17
Malacocottus zonurus	0.83	0.002	20	0.54	0.001	19
Hemitripterus bolini	0.83	0.002	21	1.73	0.002	13
Bathyraja taranetzi	0.67	0.002	22	0.27	0.000	25
Liponema brevicorne	0.65	0.002	23	0.18	0.000	28
Pandalus borealis	0.52	0.001	24	0.31	0.000	23
Asteronyx loveni	0.45	0.001	25	0.01	0.000	58

Table 4.--Continued.

Depth Stratum 2 - 367-549 m	Mudsweep Tows			Rockhopper Tows		
Species Name	CPUE (kg/ha)	Proportion of CPUE	Rank	CPUE (kg/ha)	Proportion of CPUE	Rank
Albatrossia pectoralis	281.86	0.641	1	143.94	0.546	1
Atheresthes stomias	27.09	0.062	2	15.09	0.057	4
Reinhardtius hippoglossoides	23.80	0.054	3	16.45	0.062	2
Bathyraja aleutica	23.54	0.054	4	15.21	0.058	3
Hippoglossoides elassodon	12.42	0.028	5	7.99	0.030	9
Sebastes borealis	10.29	0.023	6	10.35	0.039	5
Sebastolobus alascanus	8.67	0.020	7	8.13	0.031	8
Atheresthes evermanni	7.91	0.018	8	9.12	0.035	6
Hippoglossus stenolepis	6.21	0.014	9	8.45	0.032	7
Glyptocephalus zachirus	6.05	0.014	10	3.42	0.013	11
Hemitripterus bolini	5.34	0.012	11	5.89	0.022	10
Bothrocara brunneum	4.21	0.010	12	2.38	0.009	14
Anoplopoma fimbria	4.15	0.009	13	3.16	0.012	12
Bathyraja lindbergi	2.08	0.005	14	0.64	0.002	21
Bathyraja minispinosa	2.08	0.005	15	1.19	0.005	16
Bathyraja maculata	2.03	0.005	16	1.39	0.005	15
Lycodes concolor	0.91	0.002	17	0.48	0.002	23
Bathyraja interrupta	0.90	0.002	18	0.50	0.002	22
Somniosus pacificus	0.87	0.002	19	2.58	0.010	13
Liponema brevicorne	0.80	0.002	20	0.39	0.001	25
Chionoecetes tanneri	0.76	0.002	21	0.04	0.000	49
Ceramaster patagonicus	0.61	0.001	22	0.18	0.001	31
Careproctus melanurus	0.59	0.001	23	0.36	0.001	26
Lithodes aequispina	0.56	0.001	24	0.85	0.003	17
Theragra chalcogramma	0.47	0.001	25	0.20	0.001	30

Depth Stratum 3 - 550-732 m	Mudsweep Tows			Rockhopper Tows		
Species Name	CPUE (kg/ha)	Proportion of CPUE	Rank	CPUE (kg/ha)	Proportion of CPUE	Rank
Albatrossia pectoralis	239.99	0.556	1	93.28	0.419	1
Somniosus pacificus	95.40	0.221	2	62.52	0.281	2
Coryphaenoides cinereus	30.45	0.071	3	23.01	0.103	3
Reinhardtius hippoglossoides	12.86	0.030	4	7.08	0.032	4
Anoplopoma fimbria	10.46	0.024	5	6.08	0.027	5
Atheresthes evermanni	6.27	0.015	6	5.97	0.027	6
Bothrocara brunneum	5.24	0.012	7	5.47	0.025	7
Sebastolobus alascanus	4.62	0.011	8	5.28	0.024	8
Chionoecetes tanneri	3.94	0.009	9	0.91	0.004	13
Bathyraja lindbergi	3.34	0.008	10	2.58	0.012	9
Bathyraja aleutica	2.66	0.006	11	1.58	0.007	11
Ophiura sp.	2.06	0.005	12	0.00	0.000	82
Bathyraja maculata	1.82	0.004	13	1.66	0.007	10
Hippoglossus stenolepis	1.71	0.004	14	1.53	0.007	12
Parastichopus sp.	1.47	0.003	15	0.62	0.003	15
Atheresthes stomias	1.47	0.003	16	0.34	0.002	16
Lycodes concolor	0.98	0.002	17	0.68	0.003	14
Bathyraja minispinosa	0.69	0.002	18	0.34	0.002	17
Lithodes aequispina	0.69	0.002	19	0.26	0.001	21
Crossaster borealis	0.67	0.002	20	0.31	0.001	19
Lithodes couesi	0.52	0.001	21	0.28	0.001	20
Chionoecetes angulatus	0.38	0.001	22	0.03	0.000	43
Bathyraja trachura	0.33	0.001	23	0.03	0.000	46
Aphrocallistes vastus	0.26	0.001	24	--	--	--
Careproctus melanurus	0.26	0.001	25	0.08	0.000	30

Table 4.--Continued.

Depth Stratum 4 - 733-914 m	Mudsweep Tows			Rockhopper Tows		
Species Name	CPUE (kg/ha)	Proportion of CPUE	Rank	CPUE (kg/ha)	Proportion of CPUE	Rank
Albatrossia pectoralis	806.23	0.874	1	112.87	0.547	1
Coryphaenoides cinereus	64.29	0.070	2	53.86	0.261	2
Reinhardtius hippoglossoides	8.17	0.009	3	8.54	0.041	3
Somniosus pacificus	7.41	0.008	4	7.47	0.036	4
Anoplopoma fimbria	6.38	0.007	5	5.48	0.027	5
Chionoecetes tanneri	4.84	0.005	6	1.06	0.005	10
Chionoecetes angulatus	3.97	0.004	7	0.61	0.003	13
Atheresthes evermanni	3.80	0.004	8	3.39	0.016	6
Bathyraja aleutica	2.70	0.003	9	0.75	0.004	11
Bothrocara brunneum	1.86	0.002	10	1.35	0.007	9
Bathyraja lindbergi	1.36	0.001	11	1.60	0.008	8
Sebastolobus alascanus	1.30	0.001	12	2.88	0.014	7
Bathyraja trachura	1.04	0.001	13	0.67	0.003	12
Embassichthys bathybius	0.88	0.001	14	0.15	0.001	25
Benthoctopus sp.	0.70	0.001	15	0.08	0.000	31
Bathyraja minispinosa	0.63	0.001	16	0.07	0.000	34
Paragorgia arborea	0.58	0.001	17	0.10	0.000	29
Nearchaster variabilis	0.47	0.001	18	0.08	0.000	32
Crossaster borealis	0.42	0.000	19	0.04	0.000	42
Lycodes concolor	0.38	0.000	20	0.54	0.003	14
Lophaster furcilliger	0.35	0.000	21	0.07	0.000	33
Lithodes aequispina	0.34	0.000	22	0.38	0.002	17
Lithodes couesi	0.31	0.000	23	0.06	0.000	36
Psychrolutes phrictus	0.31	0.000	24	0.21	0.001	23
Coryphaenoides acrolepis	0.28	0.000	25	0.27	0.001	19

Depth Stratum 5 - 915-1097 m	Mudsweep Tows			Rockhopper Tows		
Species Name	CPUE (kg/ha)	Proportion of CPUE	Rank	CPUE (kg/ha)	Proportion of CPUE	Rank
Albatrossia pectoralis	171.31	0.618	1	119.70	0.659	1
Coryphaenoides cinereus	45.31	0.164	2	33.40	0.184	2
Brisaster sp.	8.97	0.032	3	0.03	0.000	59
Chionoecetes angulatus	8.78	0.032	4	3.23	0.018	4
Lycodes concolor	6.32	0.023	5	1.73	0.010	8
Reinhardtius hippoglossoides	5.96	0.021	6	5.05	0.028	3
Bothrocara brunneum	4.46	0.016	7	2.15	0.012	7
Psychrolutes phrictus	3.51	0.013	8	1.64	0.009	9
Pannychia sp.	3.00	0.011	9	0.90	0.005	11
Coryphaenoides acrolepis	2.98	0.011	10	3.17	0.017	5
Anoplopoma fimbria	2.07	0.007	11	2.29	0.013	6
Somniosus pacificus	1.71	0.006	12	1.52	0.008	10
Bathyraja trachura	1.60	0.006	13	0.88	0.005	12
Bathyraja minispinosa	0.89	0.003	14	0.09	0.000	31
Brisingella sp.	0.74	0.003	15	0.06	0.000	47
Benthoctopus leiodema	0.70	0.003	16	0.31	0.002	16
Bathyraja aleutica	0.67	0.002	17	0.42	0.002	14
Sebastolobus alascanus	0.60	0.002	18	0.30	0.002	17
Aphrocallistes vastus	0.59	0.002	19	0.06	0.000	45
Myoxoderma sacculatum	0.57	0.002	20	0.10	0.001	29
Atheresthes evermanni	0.53	0.002	21	0.25	0.001	19
Nearchaster variabilis	0.49	0.002	22	0.08	0.000	36
Buccinum scalariforme	0.32	0.001	23	0.05	0.000	52
Paractinostola faeculenta	0.30	0.001	24	0.16	0.001	23
Chrysaora melanaster	0.28	0.001	25	0.19	0.001	22

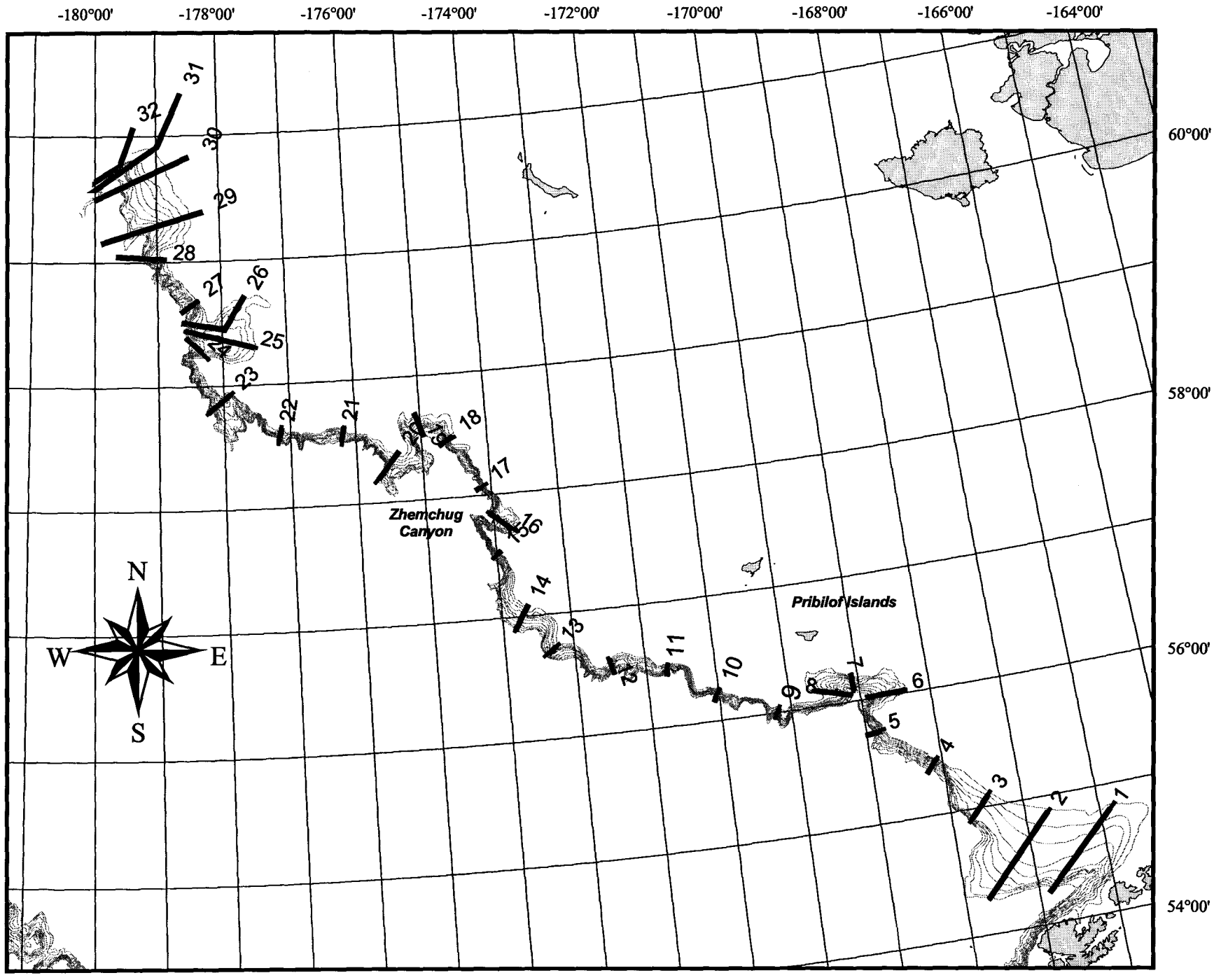

Figure 1.--Survey area and sampling tracklines for the 2000 Bering Sea bottom trawl survey of continental slope groundfish and shellfish resources. Depth contours (100 m) from 200 to 1,100 m are shown.

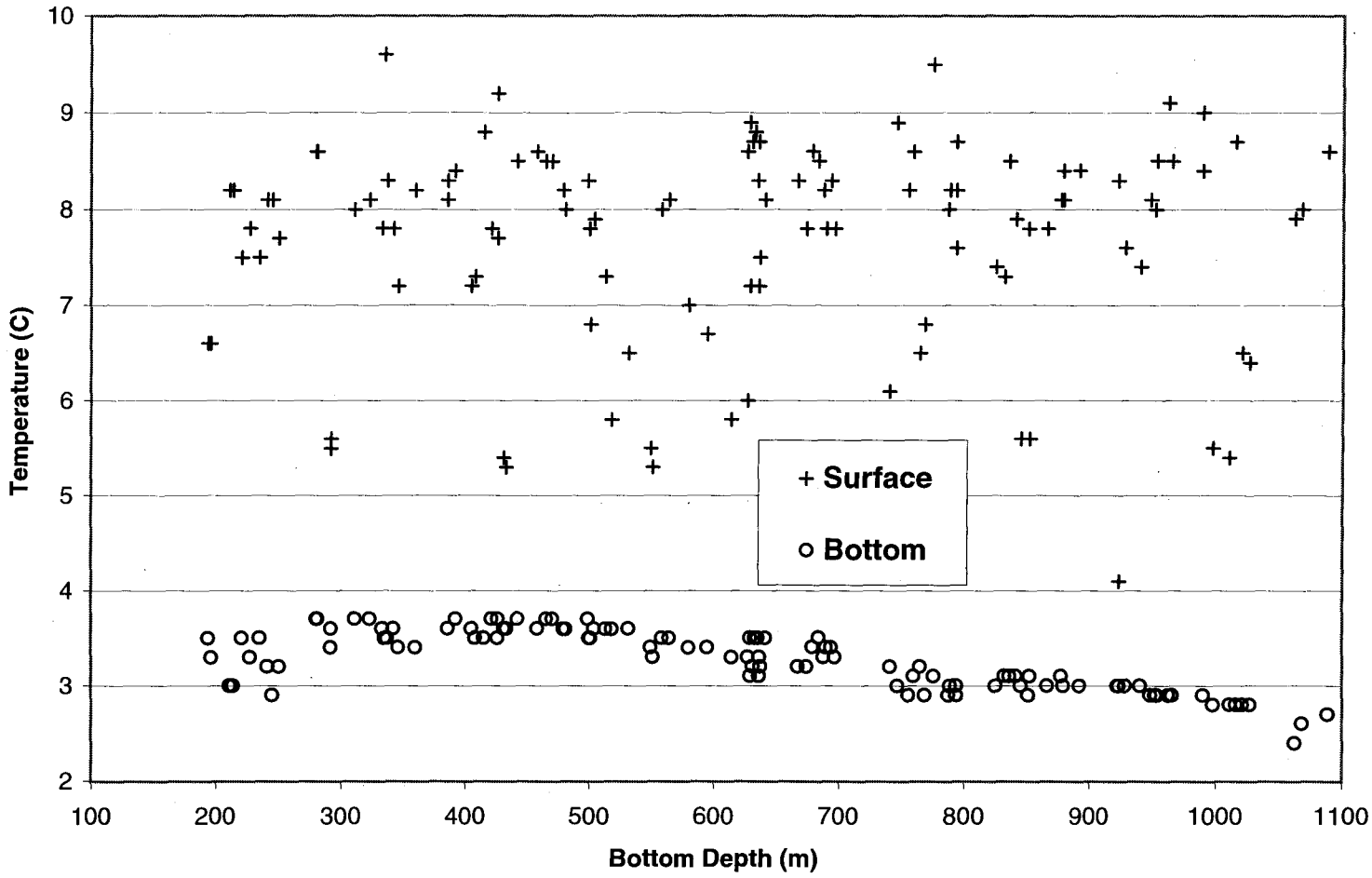

Figure 2.--Surface and bottom temperatures measured at each station plotted against the bottom depth.

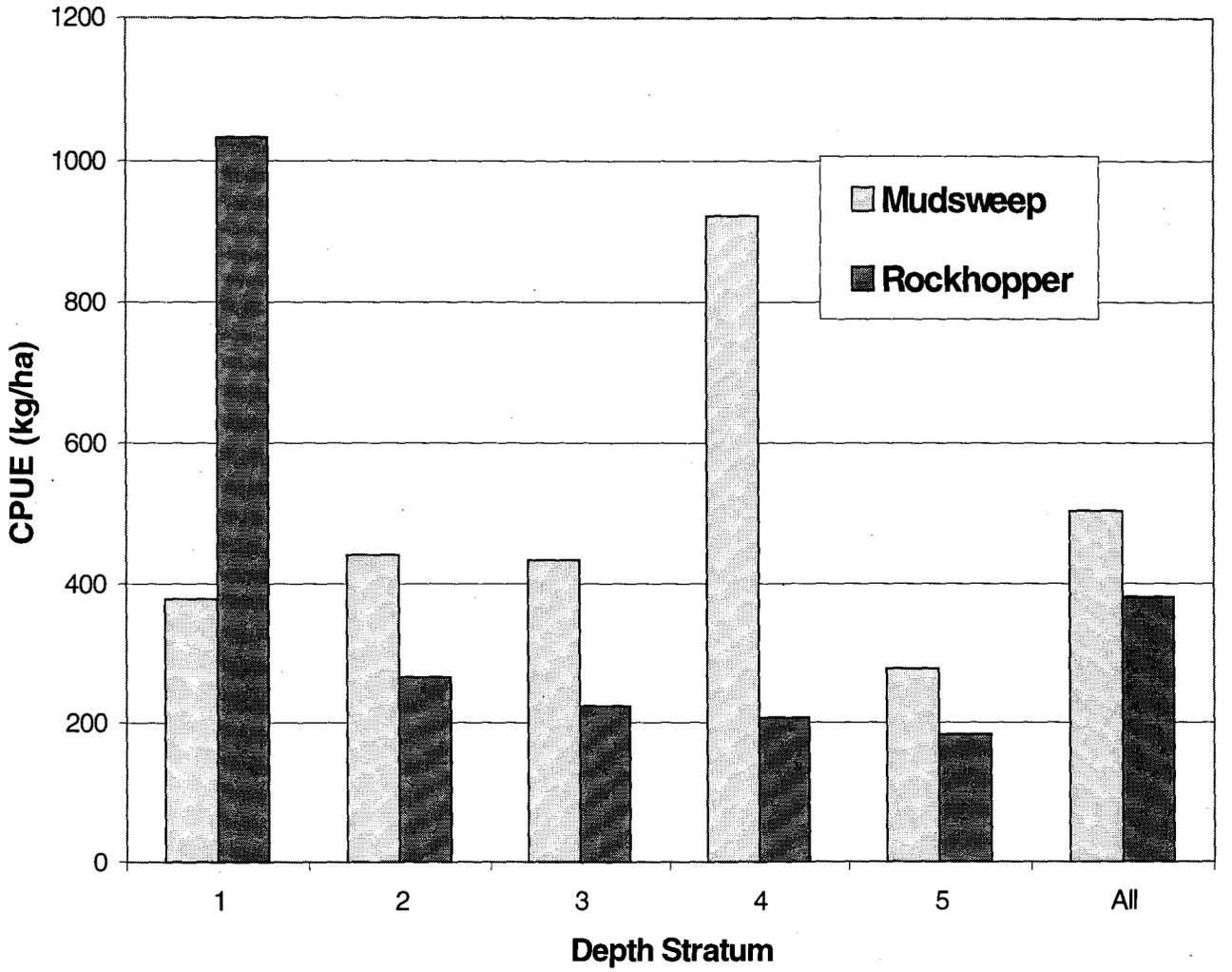

Figure 3.--Comparison of average total catch rates (all species combined) from the two gear types used during the 2000 bottom trawl survey of Bering Sea continental slope groundfish and shellfish resources. Average total catch rates are shown for each depth stratum and for all strata combined.

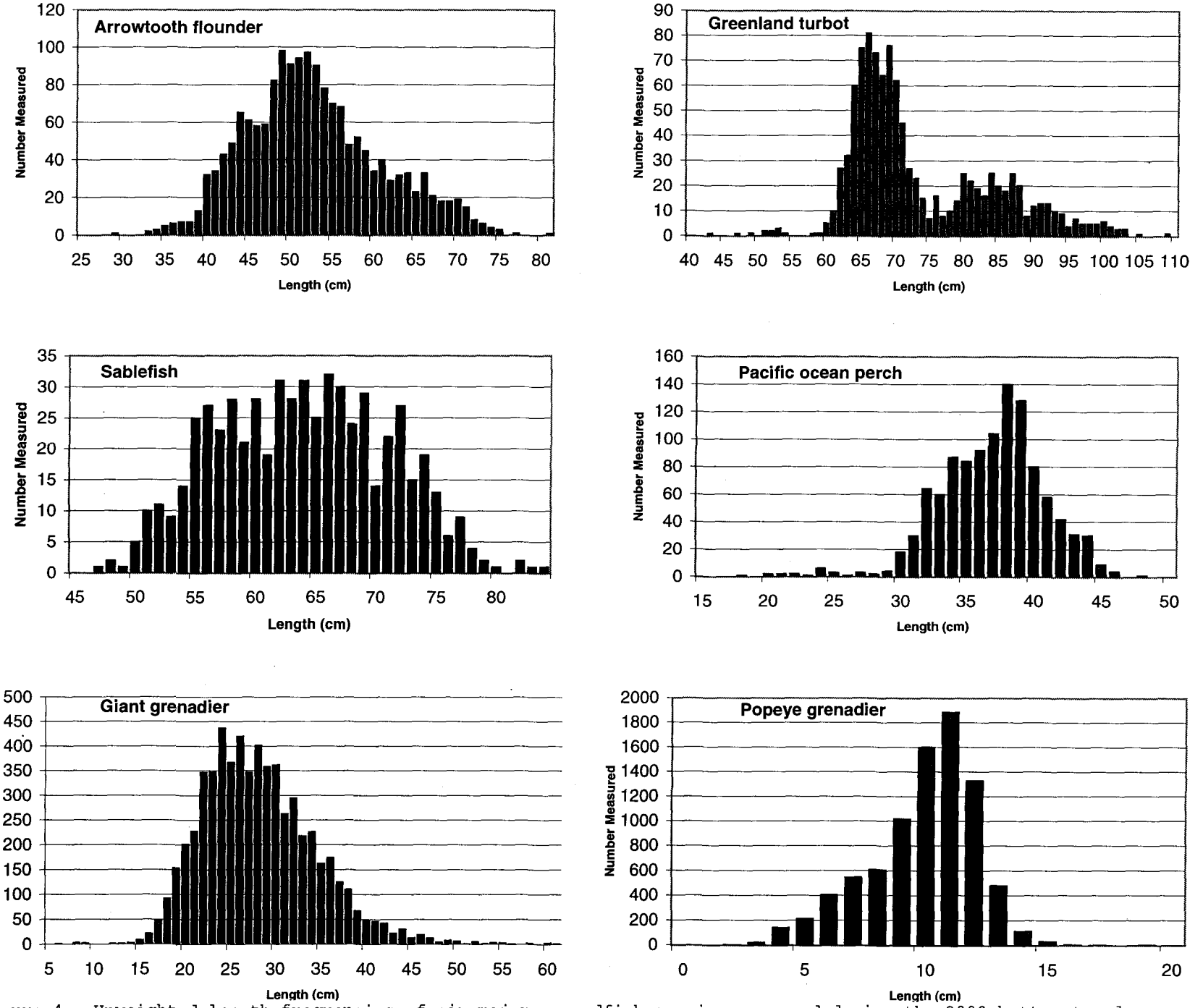

Figure 4.--Unweighted length frequencies of six major groundfish species measured during the 2000 bottom trawl survey of Bering Sea groundfish resources. Data from all depth strata have been pooled.